

Stability Improvement of the Active Grating Monochromator at NSRRC

Presenting author: Chao-Chih Chiu, Duan-Jen Wang
National Synchrotron Radiation Research Center, Taiwan.

Corresponding author: Chao-Chih Chiu
Email: chiu.cc@nsrrc.org.tw

Co-author(s): Duan-Jen Wang, Liang-Jen Huang, Shang-Wei Lin, Hok-Sum Fung
National Synchrotron Radiation Research Center, Taiwan.

Theme: Stability Improvement of the Active Grating Monochromator at NSRRC

Abstract:

Angle stability of the active grating monochromator (AGM) system is essential to achieve the ultra-high resolution in the inelastic scattering beamline at NSRRC. In this report, the upgrade of the AGM is described. The grating holder is vibration isolated from the chamber by vacuum bellows. The supporting of the chamber and grating is fixed on a common granite base, which is seated on a flat steel plate glued to ground. The angle stability of the grating is measured by the autocollimator. The performance of grating scanning mechanism is also measured.

1-Introduction

In a soft x-ray beamline, a monochromator plays a key role in energy resolution. A grating of fixed radius and dragon-type design [1] yielded an energy resolution about 10,000, but an active grating [2] with slope error only 0.1~0.3 rad proposes a possibility to attain resolution about 30,000. We used an active grating monochromator (AGM) with entrance-arm length 3.5 m, exit- arm length 2.5 m and angular deviation 174° to test the performance of the active grating. The calculated AGM angular dispersion is about 34 meV/μrad at 870 eV. The angular vibration of the AGM at a μrad level then becomes a main limiting factor for the energy resolution of the system. Here we describe the improvement of mechanical stability of the active grating monochromator and the resulting performance.

2- Mechanical design

2.1 AGM system

The new AGM system includes a grating chamber, grating and bender, mechanisms for scanning and adjustment, water cooling, granite base etc., as shown in Figure 1. The mechanical stability and the resolution of the scan motion are the design considerations. We describe here the chamber; other details are presented in the following section.

The grating chamber is cylindrical and sealed with a specially designed CF flange (OD 22 inch, PCD 519 mm and 48 bolt holes). It is mounted vertically on granite and all mechanisms are installed on the bottom flange. The scan rotation axis and grating height are easily aligned before connecting the chamber. Three flanges with bellows on the bottom flange serve for kinematic mounting of the base plate of the grating scan on the vacuum side. Some flanges for the grating actuators and water cooling are also on the bottom flange. The total chamber and mechanism are supported on granite that is anchored on a flat steel plate glued to the floor.

2.2 Scan drive

The range of a scan was designed to be about 3° , with resolution 0.2° rad. The scan mechanism consists of a rotation axis on the base plate, a sine arm and a swinging grating holder. The base plate in the chamber is seated on three adjustable kinematic mounts, and is connected to the granite base on the air side through three bellows. The rotation axis is aligned with a theodolite to the designed height and to be orthogonal to the beam direction. The bearing of the rotation axis is compatible with ultra-high vacuum. The sine arm connects an ultra-precise linear stage (Micos, UPM-160, resolution 5 nm) on the air side and through the bellows to the swing holder, with both directions flexible. To increase the stability and to decrease the vibration of the cantilever pendulum, a fully counterbalanced weight was added to the scan mechanism to balance the weight on the grating holder. To decrease the load on the driving motor and to increase the scanning resolution, a spring was added to compensate the vacuum force on the bellows.

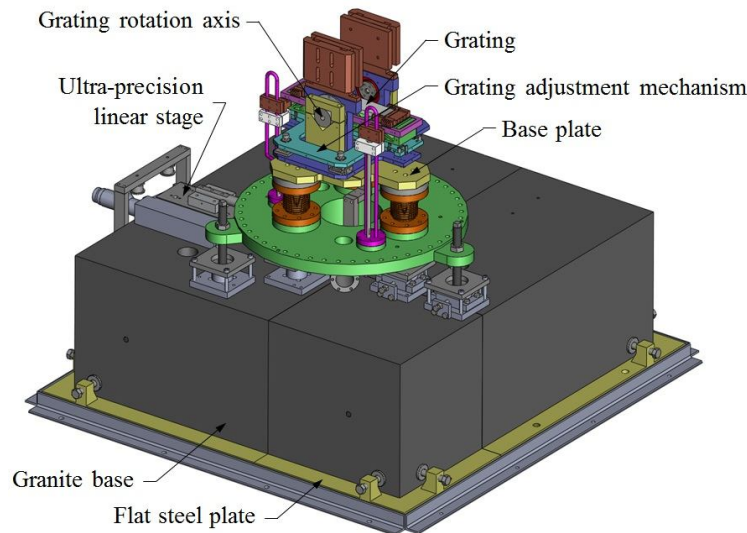


Figure 1. Major mechanisms in the AGM include a grating, a swing grating holder, a base plate, a grating rotation axis, a linear stage, water cooling, a bottom flange and a granite base assembly.

2.3 Mechanism of grating adjustment

The mechanism to adjust the grating enables fine tuning of the grating position and angle in the grating installation. It offers a manual fine adjustment of X , Y , Z , pitch, roll and yaw, as illustrated in Figure 2. It is a standard 3-point (cone, V, flat) kinematic mounting. The designed ranges in X , Y , Z are 5 mm; the angular range is about 20 mrad. The designed resolutions of the X , Y and Z adjustments are 7, 7 and 10 μm , and of the pitch, roll and yaw are about 5 μrad . A Z1-screw (cone) is designed at the center of grating for fine adjustment of the height of the grating surface to a designed value. Z2 and Z3 are for the flat and groove kinematic mounts. The grating is installed on its supporting plate with spring clamping.

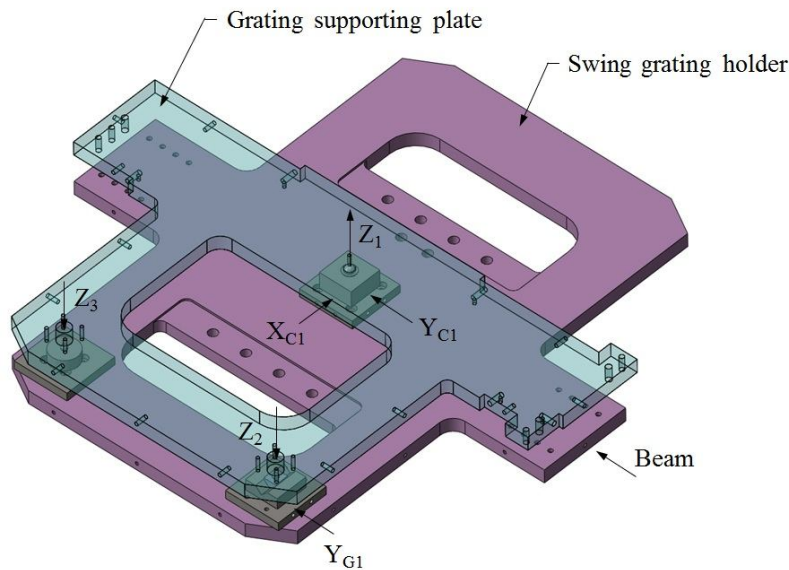


Figure 2. Mechanism of fine adjustment of the grating in X , Y , Z , pitch, roll and yaw.

2.4 Design of water cooling for the grating

We adopted a flexible thermal link with small vibration to cool the grating (2.4 W). It is made with copper braid to connect to the grating and an OFHC pipe as shown in Figure 3. The thermal links are made with a swaging method, which can decrease thermal resistance 21 % better than soldering [3]. The pipes for the cooling water are mounted on the bottom flange (22 in) with 35 CF flanges.

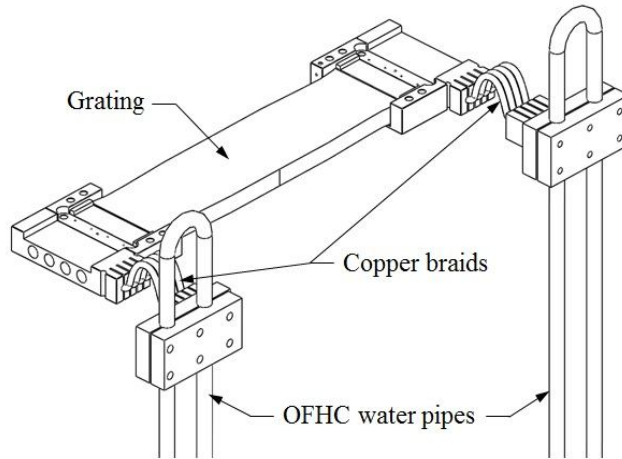


Figure 3. Water cooling for the grating with a flexible thermal link made with a swaging method.

3-Performance of the improved AGM system

Figure 4 shows the new and old AGM systems installed at the inelastic scattering beamline at NSRRC. The old system used a horizontal grating chamber, which was fixed on the steel frame; the grating was fixed on an invariant steel block on the ground. The new system is designed with a vertical grating chamber; the mechanisms to adjust the grating are fixed on a common granite base, as illustrated in Figure 4(b). The new design has a superior installation and provides more stable support for the grating.

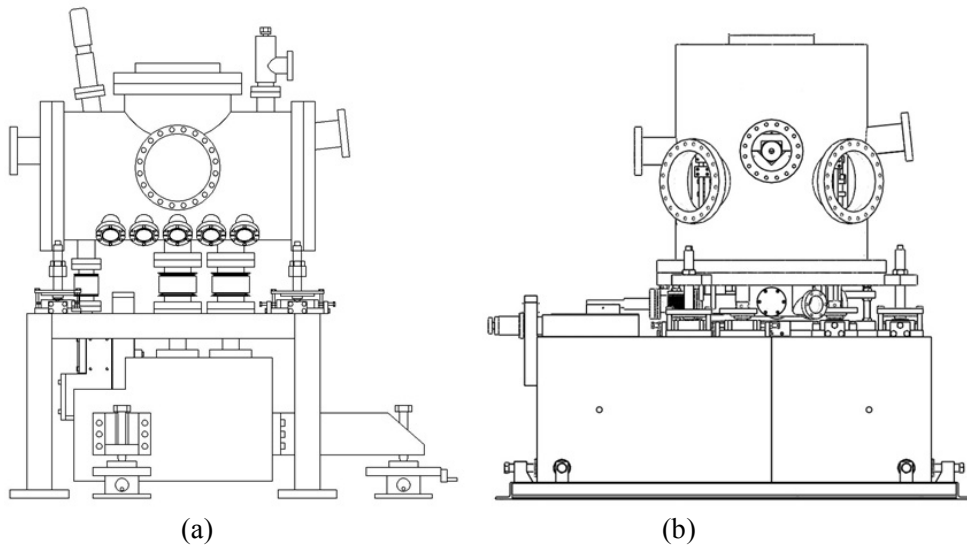


Figure 4. AGM system (a) old system, (b) new system.

To evaluate the vibrational performance of the AGM system, we measured the vibration of the ground, granite base and chamber in the vertical direction. Figure 5 shows the data, with the integrated displacement from 4-100 Hz in the inset. The result shows that the vertical displacement of the ground, granite base and chamber were all about 50 nm. It indicates that the vibrational amplification by the granite base and epoxy grouting scheme was negligible.

The angular resolution was measured with an autocollimator (Newport, LDS), as illustrated in Figure 6. The angular stabilities were measured with the same autocollimator, as shown in Figure 7. The result shows the angular stability of the new system to be $0.17 \mu\text{rad}$ rms, whereas for the old system about $0.4 \mu\text{rad}$. According to these results, the new AGM system can provide an angular stability improved relative to the old system.

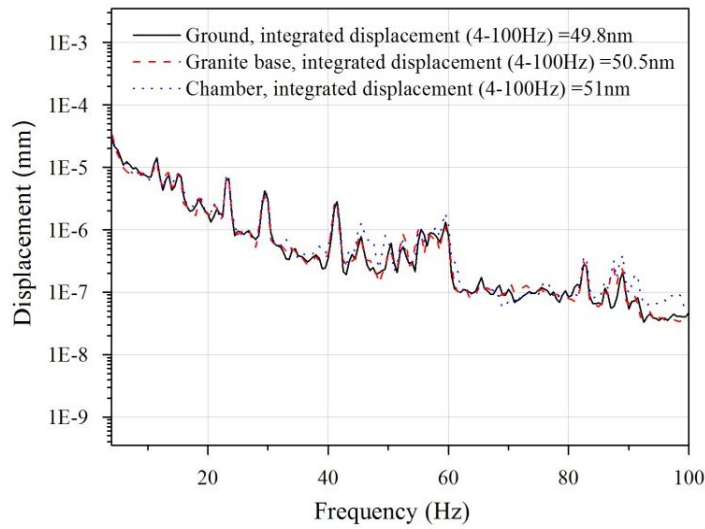


Figure 5. Comparison of the vertical displacement of the ground, granite base and chamber.

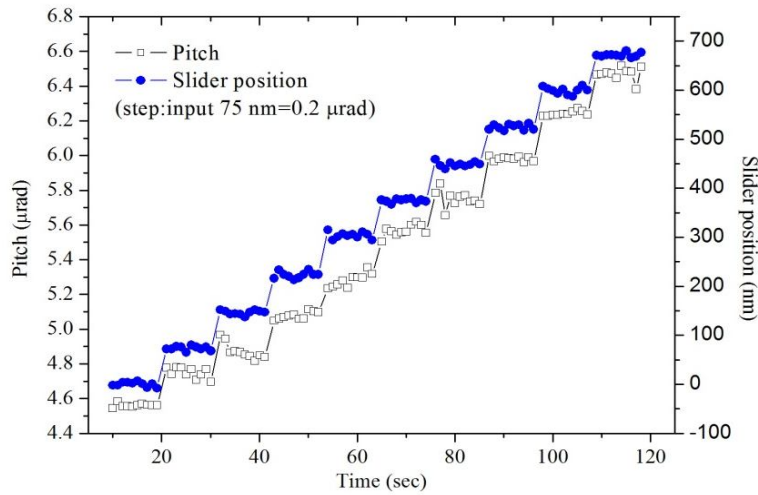


Figure 6. Angular resolution of the scan mechanism attains $0.2 \mu\text{rad}$.

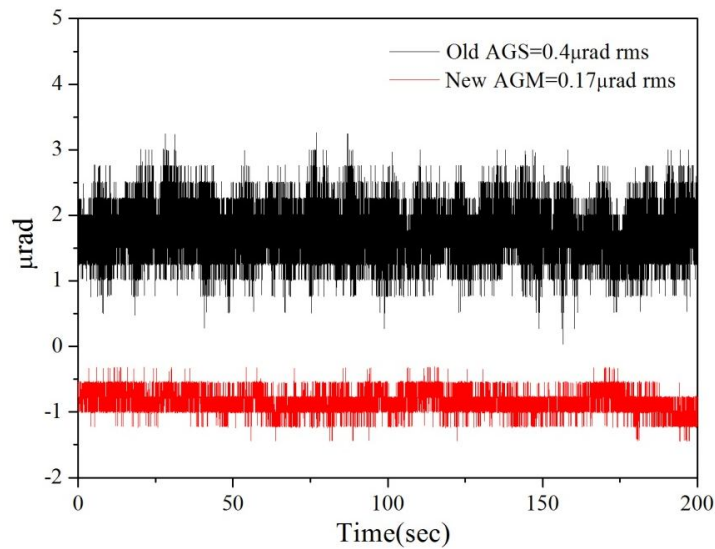


Figure 7. Angular stability of the new AGM system measured with an autocollimator.

4 Conclusion

This paper describes the design and installation of the active grating monochromator. Some improvement and performance are summarized as follows.

1. All components inside the grating chamber are mounted on a specially designed CF 22-inch bottom flange, which is convenient for the installation and alignment of the grating before the chamber installation.
2. The angular resolution of the grating scan mechanism in the pitch direction attains 0.2 μrad .
3. The angular stability of the improved AGM system is about 0.17 $\mu\text{rad rms}$.

References

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